# Task 22 of IEA HIA – Fundamental and Applied Hydrogen Storage Materials Development

B.C. Hauback

This document appeared in

Detlef Stolten, Thomas Grube (Eds.):
18th World Hydrogen Energy Conference 2010 - WHEC 2010
Parallel Sessions Book 4: Storage Systems / Policy Perspectives, Initiatives and Co-operations
Proceedings of the WHEC, May 16.-21. 2010, Essen
Schriften des Forschungszentrums Jülich / Energy & Environment, Vol. 78-4
Institute of Energy Research - Fuel Cells (IEF-3)
Forschungszentrum Jülich GmbH, Zentralbibliothek, Verlag, 2010
ISBN: 978-3-89336-654-5

# Task 22 of IEA HIA – Fundamental and Applied Hydrogen Storage Materials Development

**Bjørn C. Hauback**, Institute for Energy Technology, Norway

During the last decade there has been a significant increased focus on hydrogen as the future energy carrier. The main reason is that a hydrogen economy may be an answer to the two major challenges facing the future global economy: climate changes and the security of energy supplies. The major components in the expected Hydrogen Economy involve production, storage and final use of hydrogen, e.g. in fuel cells. All parts in this chain are facing considerable technological challenges, in particular related to the key materials.

Hydrogen storage is a crucial step for providing a ready supply of hydrogen fuel to an end user, such as a car. Without effective storage systems, a Hydrogen Economy will be difficult to achieve. Hydrogen storage remains an undisputed problem for hydrogen- fuelled vehicles, and is considered by many to be the most technologically challenging aspect. During the years several countries have defined targets for hydrogen storage, for example US Department of Energy (DOE), NEDO in Japan and the European Commission in projects like NESSHY. These targets include a number of parameters important for practical hydrogen storage systems. One example is the targets given by US DOE. The most cited target for 2010 is 4.5 wt% hydrogen system gravimetric capacity for applications in vehicles. Compressed or liquid hydrogen will never meet these long-term goals for hydrogen storage. Main problems with liquid and compressed hydrogen storage are energy losses during liquefaction (30-40 %) and compression, volumetric and gravimetric densities (most severe for compressed hydrogen) and safety considerations. Thus the only potential long-term solution is hydrogen storage in solid materials in vehicles.

In spite of the significant achievements related to hydrogen storage in solid materials during the last years, further progress is still needed to fulfil the international goals, e.g. with respect to gravimetric and volumetric capacities, temperature and pressure for hydrogen release for mobile applications. Such research efforts will require new materials and solutions, and not simple, incremental improvements in current technologies. However, for stationary applications, there exist materials with acceptable properties. The gap between the present storage solutions and the storage system targets defined by US DOE is shown in figure 1. A solution requires collaboration optimizing competence and knowledge in different research groups worldwide. The International Energy Agency Hydrogen Implementation Agreement (IEA HIA) Task 22 “Fundamental and applied hydrogen storage materials development” is the largest international co-operative effort on hydrogen storage materials and by the end of 2009 with participation of 53 leading experts in the field from 18 countries including: Australia, Canada, Denmark, European Commission, France, Germany, Greece, Iceland, Italy, Japan, Korea, Lithuania, Norway, Netherlands, Sweden, Switzerland, United Kingdom and USA.

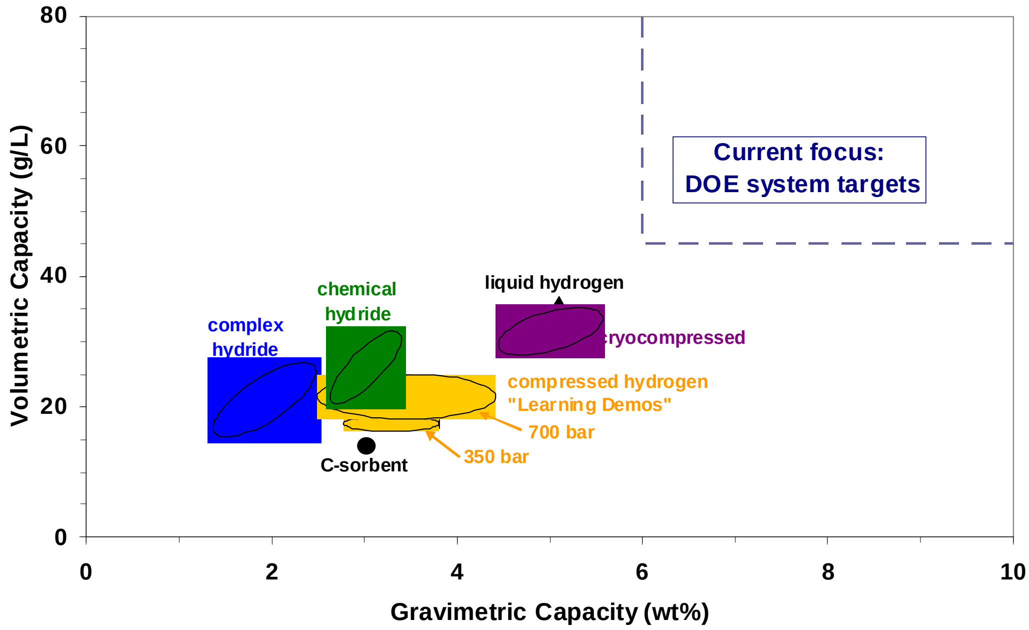


**Figure 1: Volumetric hydrogen capacity (g/L) versus gravimetric capacity (wt%) for different hydrogen storage vehicle systems (Source: G. Sandrock, G. Thomas, U.S. DOE, 2008).**

The major challenges related to materials for hydrogen storage can be summarized by:

- Gravimetric hydrogen density. A very few hydrogen storage materials reach a metal/hydrogen ratio higher than 2-3, and thus hydrogen storage materials fulfilling international goals should be based on light-weight elements.
- Thermodynamics. The release of hydrogen should take place at conditions (temperature and pressure) matching working conditions, for example for fuel cells.
- Reversibility. Important for on-board storage, but for off-board hydrogen regenerative hydrogen storage materials the hydrogen uptake should be a cheap and simple process.
- Kinetics. The use of catalysts is often important, but also use of nanoscale materials will improve the kinetics.

In addition, several other factors are of importance like availability of the elements and compounds, cost issues and safety.

Different classes of materials for hydrogen storage have been intensively studied during the last decades, the main groups of compounds are:

- Reversible metal hydrides
- Regenerative hydrogen storage materials (chemical hydrides)
- Nanoporous materials
- Rechargeable organic liquids and solids.


**Figure 2: Participants at the Task 22 IEA HIA Experts Meeting in Jeju Island, Korea in April 2009.**

Task 22 of IEA HIA addresses hydrogen storage in solid materials. The research efforts related to development of materials for use in vehicles will require *new* materials and solutions, and not simple, incremental improvements in current technologies. Phase 1 of Task 22 ended in December 2009 after 3 years and phase 2 has started for a new 3-years period.

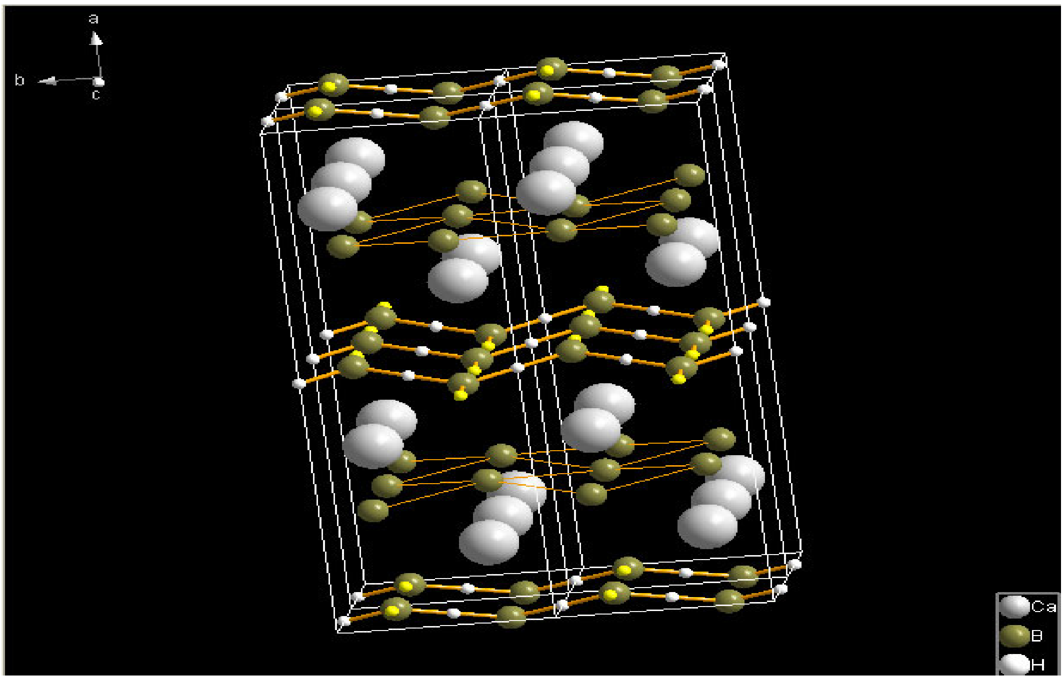


**Figure 3: A promising hydrogen storage material: The intermediate phase of $Ca(BH_4)_2$ (source: Institute for Energy Technology).**

The specific goals and objectives for research on hydrogen storage materials in Task 22 are:

1. Develop a reversible or regenerative hydrogen storage medium fulfilling international targets for hydrogen storage.
2. Develop the fundamental and engineering understanding of hydrogen storage by various hydrogen storage media that have the capability of meeting Target A.
3. Develop hydrogen storage materials and systems for use for mobile and stationary applications and also other potential energy related applications, for example in batteries.

The targets are not quantitative but instead refer to national and international targets. This gives more flexibility and will also include other relevant parameters than the conventional weigh percentage and hydrogen release temperatures.